



PATENT  
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IN THE U.S. PATENT AND TRADEMARK OFFICE

Applicant: Berryman, Walter et al. Conf.: 7385  
Appl. No.: 10/814,178 Group: UNASSIGNED  
Filed: April 1, 2004 Examiner: UNASSIGNED  
For: PUMP CONTROL SYSTEM

L E T T E R

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

August 6, 2004

Sir:

Under the provisions of 35 U.S.C. § 119 and 37 C.F.R. § 1.55(a), the applicant(s) hereby claim(s) the right of priority based on the following application(s):

<u>Country</u>	<u>Application No.</u>	<u>Filed</u>
AUSTRALIA	PR 8068	October 3, 2001

A certified copy of the above-noted application(s) is(are) attached hereto.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fee required under 37 C.F.R. §§ 1.16 or 1.17; particularly, extension of time fees.

Respectfully submitted,

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Attachment(s)

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Appl. No. 10/814,178

Filed April 1, 2004

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Atty. No. 0641-026

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I, JULIE BILLINGSLEY, TEAM LEADER EXAMINATION SUPPORT AND  
SALES hereby certify that annexed is a true copy of the Provisional specification  
in connection with Application No. PR 8068 for a patent by DAVEY  
PRODUCTS PTY LTD as filed on 03 October 2001.



WITNESS my hand this  
Second day of April 2004

JULIE BILLINGSLEY  
TEAM LEADER EXAMINATION  
SUPPORT AND SALES

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**AUSTRALIA**  
**Patents Act 1990**

**PROVISIONAL SPECIFICATION**

Invention Title: PUMP CONTROL SYSTEM

Applicant: DAVEY PRODUCTS PTY LTD

The invention is described in the following statement:

## PUMP CONTROL SYSTEM

The present invention relates generally to a pump control system. In particular the present invention relates to a sensor assembly for a pump control system.

5

A simple pump controller for controlling an irrigation, industrial or domestic water pump typically employs a pressure switch which is set to operate the pump between low and high pressure thresholds. The switch turns the pump on when the low threshold is reached and off when the high threshold is

10 reached.

One deficiency of such a controller is that the pump tends to cycle unnecessarily between the two thresholds. When a centrifugal pump is used, for example, it would be much more desirable to operate the pump continuously until the associated outlet is turned off, since running the pump at maximum pressure is not an issue.

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To achieve this, flow detection has been introduced in some prior art pump controllers in addition to pressure detection. This allows the pump to turn off in the absence of flow but adds considerable complexity to the pump controller and has been achieved with sensors fundamentally different in form. Moreover, such sensors tend to have operating points that need to be manually adjusted in the field to match the output of the pump to the requirements of an installation site. In a stand alone installation (an installation to an existing pump system) it is desirable that the pump controller automatically adapts to any viable combination of installation and pump.

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Attempts have been made to address the above problems with relatively simple adaptive systems but the known solutions still all interrupt the pump causing an undesirable decline in pressure. One solution involves measuring the  
5 performance of the pump by monitoring closed head pressure. The controller may determine that pressure is required when a predetermined drop in pressure (eg. 20%) is measured and may start the pump in response to such drop in pressure.

10 The present invention addresses the problem by means of an integrated sensor system mounted to a metal substrate that is in direct contact with the flow of water or other pumped medium. The metal substrate preferably includes a stainless steel plate. The sensor system includes pressure sensing means such as a strain gauge. The strain gauge preferably includes a thick film piezo  
15 resistor mounted directly onto the dry side of the metal substrate. The sensor system includes flow sensing means utilising thermal transfer or loss measurement techniques. Flow sensing means based on thermal techniques are described in publicly available documents including WO91/19170 entitled "Flow Sensor and Control System", the disclosure of which is incorporated  
20 herein by cross reference. The flow sensing means includes a source of heat such as a heater element and a plurality of temperature sensors such as thermistors.

The heater element and the or each thermister may be printed directly onto the  
25 dry side of the metal substrate utilising thick film technology. A control unit for

controlling thresholds and operation of the system may be mounted in close proximity to the pressure / flow sensing means such as directly onto the metal substrate.

- 5 The control unit may include a microprocessor or micro controller. The control unit may have its inputs connected to the pressure sensing means and / or the flow sensing means via conductive tracks printed directly onto the dry side of the metal substrate. The metal substrate includes on its dry side, an insulator such as a ceramic to insulate the conductive tracks and other components from
- 10 the metal substrate.

Construction of the sensor system onto a common metal substrate facilitates dissipation of heat, typically from the pump switching element such as a triac. In some embodiments the triac may also serve as the source of heat for the

15 flow sensing means, dispensing with the need for a separate heater element.

Construction of sensing elements onto a metal body utilising thick film technology involving printing and firing of dielectric inks is described in publicly available documents including US5867886 entitled "Method of making a Thick

20 Film Pressure Sensor" and US6022756 entitled "Metal Diaphragm Sensor with Polysilicon Sensing Elements and Methods therefor", the disclosures of which are incorporated herein by cross reference.

A desirable feature of a sensor assembly for a pump controller is that the

25 assembly functions reliably notwithstanding that it is required to interface

directly with the pumped fluid medium under pressure. The pumped medium may present an inherently hostile environment to sensitive electronic components. The sensor assembly may be effectively isolated from the hostile environment due to its placement on the dry side of the sensor substrate.

- 5 However, it is still necessary to ensure that the dry side of the substrate is effectively sealed against ingress of moisture from the wet side. The means used for sealing the sensor assembly also should be effective in an environment in which fluid pressure causes the sensor substrate to deflect. Controlled deflection is a requirement of the sensor substrate as this transmits
- 10 information about the pressure of the fluid to the pressure sensing means on the dry side of the substrate. The sealing also needs to be achieved relatively economically for a mass produced sensor assembly.

- The sealing means may include at least a first seal element and a second seal
- 15 element. The first seal element may include an elastomeric material such as a natural or synthetic rubber. The first seal element may be adapted to substantially prevent ingress of fluid under relatively high pressure of the pumped fluid medium. The first seal element may surround an opening in a sensor housing which communicates with the pumped medium.

- 20 The first seal element may include a peripheral bead. The first seal element may be interposed between the wet side of the substrate body and a peripheral portion of the housing surrounding the opening in the housing. The elastomeric material may be chemically inert with respect to the pumped medium. The elastomeric material may be at least sufficiently resilient to allow the substrate
- 25 body to deflect incrementally whilst minimising ingress of pumped medium into

the housing. Because some ingress of medium may be unavoidable, the first seal element may include a leak path to a first chamber. The first chamber may be vented to atmospheric pressure. The first chamber may be isolated from the dry side of the substrate body by means including a second seal element.

- 5 Venting of the first chamber to the atmosphere may ensure that any high pressure leak drains to the atmosphere before it penetrates the second seal element which protects the dry side of the substrate body.

- The second seal element may include an elastomeric material such as natural or synthetic rubber. The second seal element may include a peripheral bead. The second seal may be interposed between a peripheral edge associated with the first chamber and a closure element. The closure element may include a second chamber. The second chamber may be vented to atmospheric pressure. The second seal element may be adapted to substantially prevent
- 10
  - 15
  - 20
- ingress of moisture to the second chamber. The second seal element may include a resilient wall which can respond to changes in internal pressure caused by atmospheric conditions or changes in temperature. The resilient wall may substantially prevent ingress of damp air (moisture) over time. The second chamber may be in communication with the dry side of the sensor substrate.
- The second chamber may be adapted to house electronic components associated with the sensor system.

- The first and second seal elements may be interconnected. The seal elements may be connected by means of a membrane. The membrane may be formed
- 25
- from the same material as the first and second seal elements. The membrane



may be formed integrally with the seal elements. The membrane may be shaped to envelop at least the peripheral edge of the substrate body. The sensor housing and associated closure may include one or more recesses adapted for receiving the first seal element, the second seal element and the  
5 enveloped peripheral edge of the substrate body.

The housing including the sensor assembly may be interposed upstream or downstream relative to the pump.

10 The sensor housing may include a venturi device designed to accelerate the flow of the pumped medium in the vicinity of the wet side of the substrate body. The venturi device may include a formation utilising the venturi principle to convert pressure energy associated with the flow of the pumped medium to kinetic energy through a narrowed portion of the formation. The venturi device  
15 may be located in the vicinity of an outlet in the sensing housing and may be adjacent the opening in the housing which facilitates communication of the pumped medium with the wet side of the substrate body.

According to one aspect of the present invention there is provided a pump  
20 controller adapted for controlling a pump for a fluid medium such as water, said pump controller including:

a metal substrate adapted to have one side thereof exposed to said fluid medium;

an insulating medium applied to a second side of said substrate;

pressure sensing means including at least one pressure responsive element implemented on said insulating medium closely adjacent to said substrate such that said pressure element is responsive to pressure of said fluid medium when said one side is exposed to said fluid medium;

- 5 flow sensing means including at least one source of heat and at least one temperature responsive element implemented on said insulating medium closely adjacent to said substrate such that said temperature responsive element is responsive to flow of said fluid medium when said one side is exposed to said flow, said fluid medium providing a sink for said source of heat
- 10 in a manner that is related to said flow;

switching means for switching said pump on or off; and

processing means for receiving data from said pressure sensing means and said flow sensing means, said data being communicated via conductive tracks implemented on said insulating medium, said processing means being adapted

15 for processing said data and for producing an output for driving said switching means.

- According to a further aspect of the present invention there is provided a housing for a sensor substrate having a wet side and a dry side and adapted to
- 20 promote contact of said wet side with a fluid medium and to substantially prevent contact of said dry side with said fluid medium, said housing including:
- a main body having an opening for said fluid medium and for receiving said sensor substrate with its wet side exposed to said opening;
- a first chamber maintained substantially at atmospheric pressure;

a closure for said housing including a second chamber exposed to said dry side of said sensor substrate; and

5 second sealing means arranged between said closure and said first chamber to substantially prevent ingress of said fluid medium to said second chamber.

To minimize cycling of the pump controller in the face of small leaks or drips (in a non resilient hydraulic circuit a small drip can cause the pressure to drop significantly) which could trigger an undesirable number of short runs of the pump, it is highly desirable to provide a leak compensating device such as an accumulator. The accumulator may be spring powered and may compensate a minimum quantity (eg. 30 cc.) of drawn off water or the like. The accumulator may be external or it may be integral with the pump controller.

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A preferred embodiment of the present invention will now be described with reference to the accompanying drawings wherein:

Fig. 1 shows an overview of the sensor system mounted to a sensor substrate;

Fig. 2 shows functional elements associated with the pressure and flow sensing means;

Fig. 3 shows a schematic circuit diagram of the electronics associated with the  
25 sensor system;

Fig. 4 is a cross section through the sensor housing showing a double seal protecting the dry side of the sensor substrate from high pressure water;

- 5 Fig. 5 shows the wet side of the sensor substrate mounted within a seal assembly;

Fig. 6 shows the dry side of the sensor substrate mounted within the seal assembly;

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Fig. 7 shows a similar view to Fig. 6 with electronic components mounted to the dry side of the sensor substrate;

- Fig. 8 shows the main body of the sensor housing for the sensor assembly with  
15 its closure member;

Fig. 9 shows the underside of the closure member;

- Fig. 10 shows the flow-sensing opening in the main housing which facilitates  
20 communication of the pumped water with the wet side of the sensor substrate;

Fig. 11 shows the sensor assembly of Fig. 6 fitted to the main housing; and

Fig. 12 shows a venturi device adjacent the flow sensing opening.

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Fig. 1 shows one form of sensor assembly 10 according to the present invention. The sensor assembly 10 includes a substrate 11 in the form of a stainless steel plate. Substrate 11 includes pressure sensing means 12 and flow sensing means 13 implemented directly onto its dry side using thick film hybrid technology. Pressure sensing means 12 contains pressure sensing elements including resistors R9, R10 in tension. As shown in Fig. 2 deflection of substrate 11 is measured by a change in value due to tension of the resistors formed by conductive tracks on substrate 11. Flow sensing means 13 includes heater 15 and temperature sensor 16. As shown in Fig. 2 flow rate is measured by detecting a measure of heat loss to the body of water being pumped adjacent the wet side of substrate 11. Substrate 11 includes micro controller 14. Micro controller 14 receives inputs from pressure sensing means 12 and flow sensing means 13 and is adapted to switch triac 17 controlling pump motor 18. Triac 17 is mounted in thermal communication with substrate 11 ensuring good dissipation of heat due to heat loss to the body of water being pumped adjacent the wet side of substrate 11. In some embodiments heater 15 may be dispensed with since its role may be performed by triac 17.

Fig. 3 shows a schematic circuit diagram of one form of sensor assembly according to the present invention. The sensor assembly includes microprocessor 30 which may comprise an ST6 family microprocessor manufactured by ST Microelectronics. The sensor assembly also includes temperature sensing means shown generally at 31 including thermistors R16 and R18.

The sensor assembly includes pressure sensing means shown generally at 32 and flow sensing means shown generally at 33. Pressure sensing means 32 includes a bridge circuit containing piezo resistors R9 and R10 and operational amplifier 34. Flow sensing means 33 is based on thermal transfer or loss measurement principles as described herein and includes a bridge circuit containing thermistors R1 and R2 and operational amplifier 35. The sensor assembly includes a triac drive for switching on a pump motor (not shown) and manual override / reset means shown generally at 36 and an LED alarm shown generally at 37.

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The sensor assembly includes a heater (for flow sensing means 33) designated by resistor R26 and a power supply shown generally at 38.

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Fig. 4 shows a cross section through the sensor housing including a seal assembly protecting the dry side 40 of sensor substrate 11. The seal assembly includes a high-pressure seal comprising a peripheral bead 41 interposed between the wet side 42 of substrate 11 and the peripheral inner edge 43 of the sensor housing adjacent flow sensing opening 49. Peripheral bead 41 is compressed by pressure applied to substrate 11 via closure 44 associated with the housing.

20

A leak path 44 is provided to vent chamber 45, which is maintained at atmospheric pressure. Vent chamber 45 is insulated from the dry side 40 of sensor substrate 11 via a secondary seal which forms part of the seal assembly. The secondary seal comprises a peripheral bead 46 interposed

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between a peripheral edge associated with vent chamber 45 and closure element 44. Bead 46 is compressed by pressure applied via closure 44. Closure 44 is fixed to the main body of the sensor housing by screws or the like. Beads 41 and 46 are formed from an elastomeric material and connected by

5 membrane 47 formed from a similar material. Membrane 47 provides an additional barrier to moisture reaching the dry side of substrate 11. Membrane 47 is substantially S-shaped in cross-section and includes recess 48 shaped to receive the peripheral edge of substrate 11.

10 Fig. 5 shows a view from the wet side of a practical embodiment of sensor substrate 11 mounted within a seal assembly 51.

Fig. 6 shows a view from the dry side of sensor substrate 11 mounted within the seal assembly 51. Fig. 6 clearly shows conductive tracks 60 and resistors 61

15 and other components printed onto substrate 11.

Fig. 7 shows electronic components associated with the sensor assembly mounted on the dry side of the sensor substrate 11.

20 Fig. 8 shows a view of the main body 80 of the housing for the sensor assembly together with its closure member 44.

Fig. 9 shows an underside view of closure member 81 including a projection 82 that is of similar outline to the flow sensing opening 49 and is adapted to apply

25 pressure to substrate 11 at least in the vicinity of the flow sensing opening 49.

Fig. 10 is a view of the main housing showing the flow sensing opening 49 nested within vent chamber 45. A peripheral recess 100 adapted to receive bead 41 of the seal assembly surrounds flow sensing opening 49.

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Fig. 11 shows the sensor substrate 11 and seal assembly 51 mounted within vent chamber 45 of main body 80 of the housing.

Fig. 12 shows an underside view of the main body 80 of the housing with the closure member removed and the flow-sensing opening 49 clearly shown. A venturi device 120 is included in the vicinity of flow sensing opening 49. Venturi device 120 is shaped approximately like a human ear to accelerate the flow of pumped water in the vicinity of opening 49.

15 It will be appreciated that various alterations, modifications and / or additions may be introduced into the constructions and arrangements of parts previously described without departing from the spirit or ambit of the invention.

20 DATED: 3 October 2001

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Attorneys for:  
Davey Products Pty Ltd

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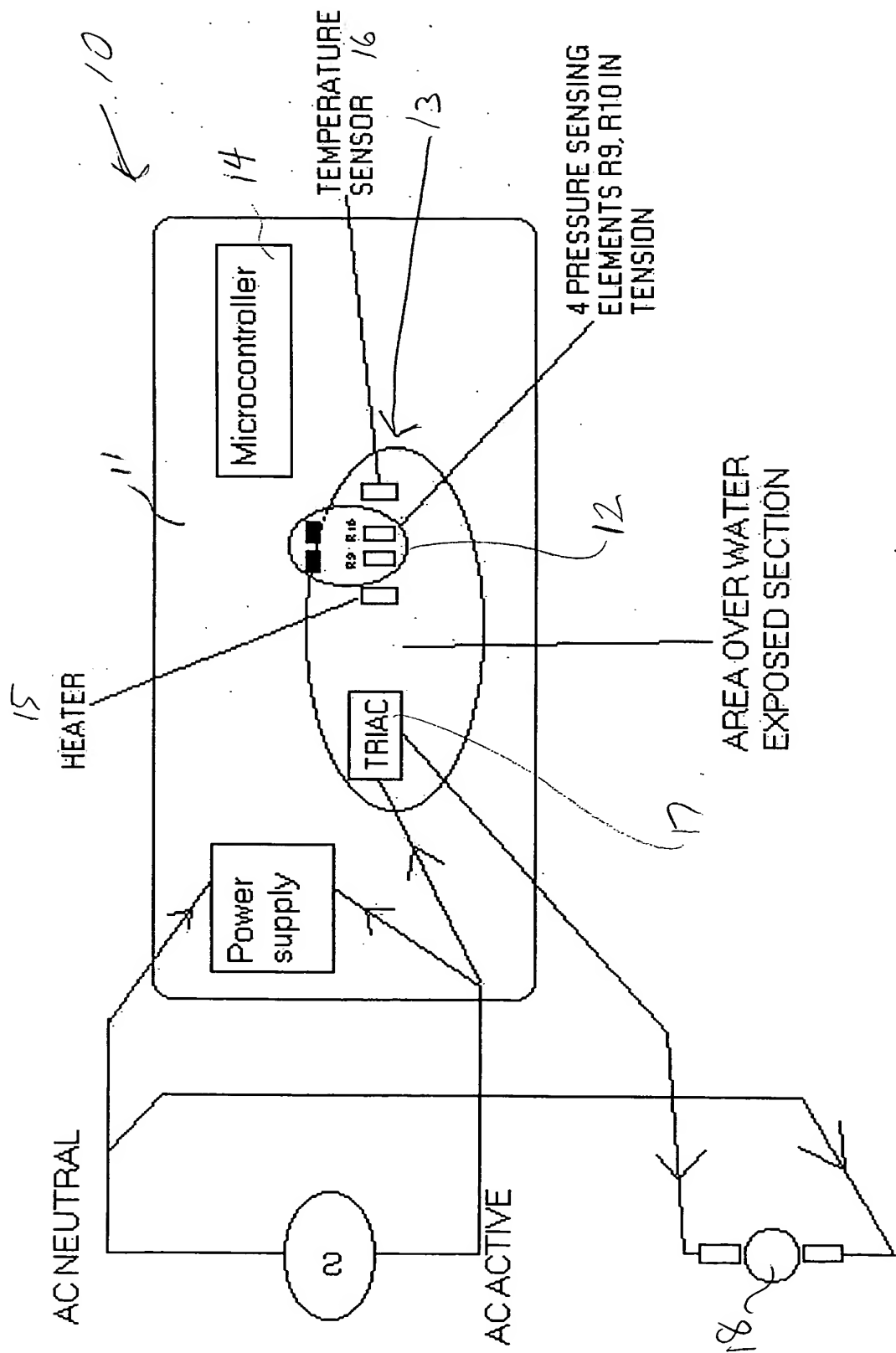


FIG 1

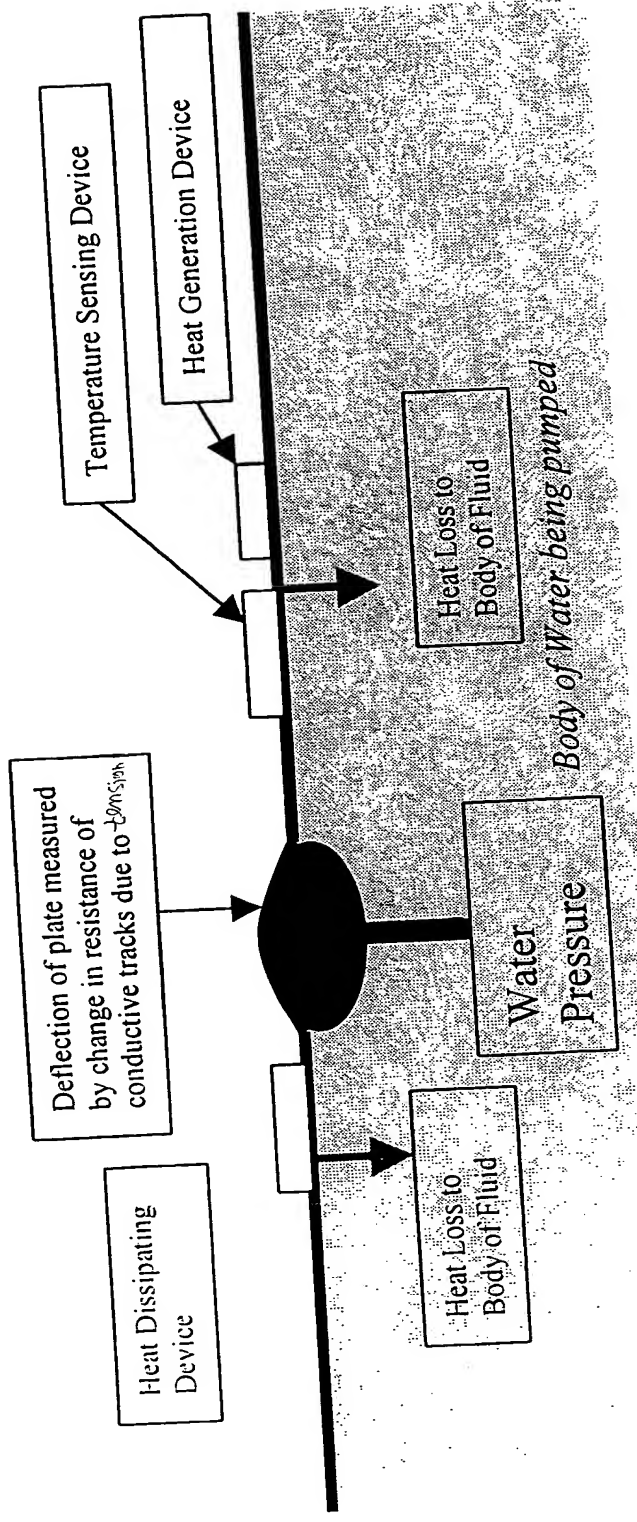


Fig 2

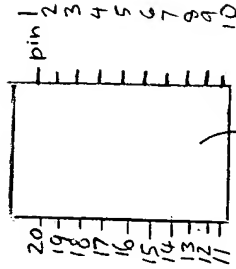
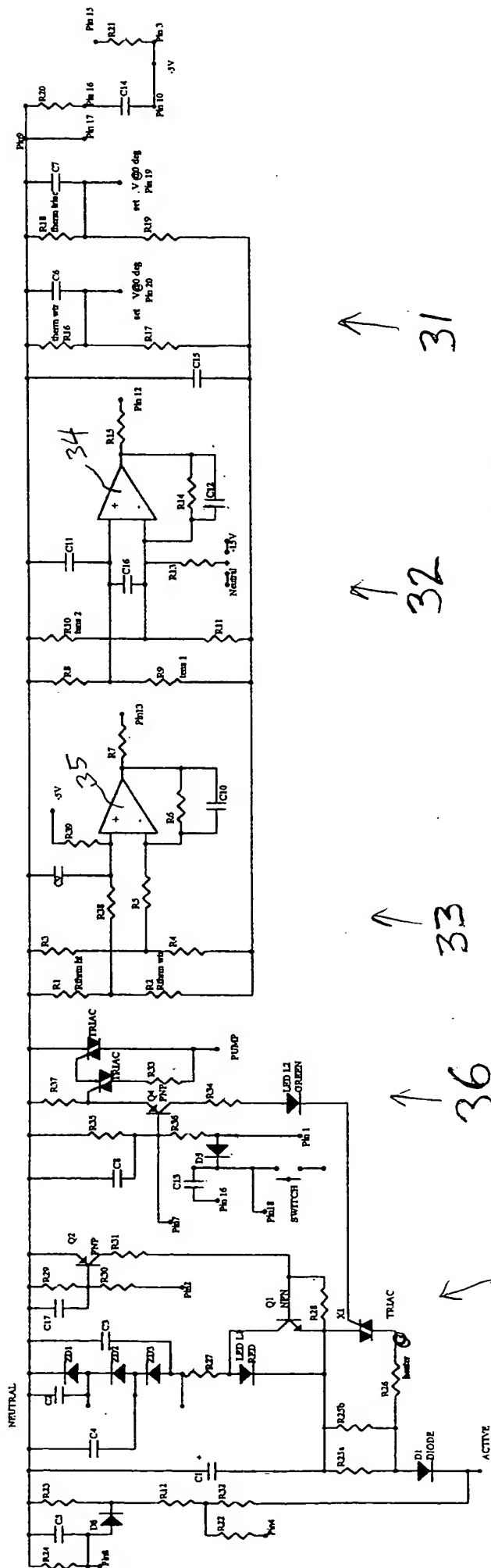


FIG 3

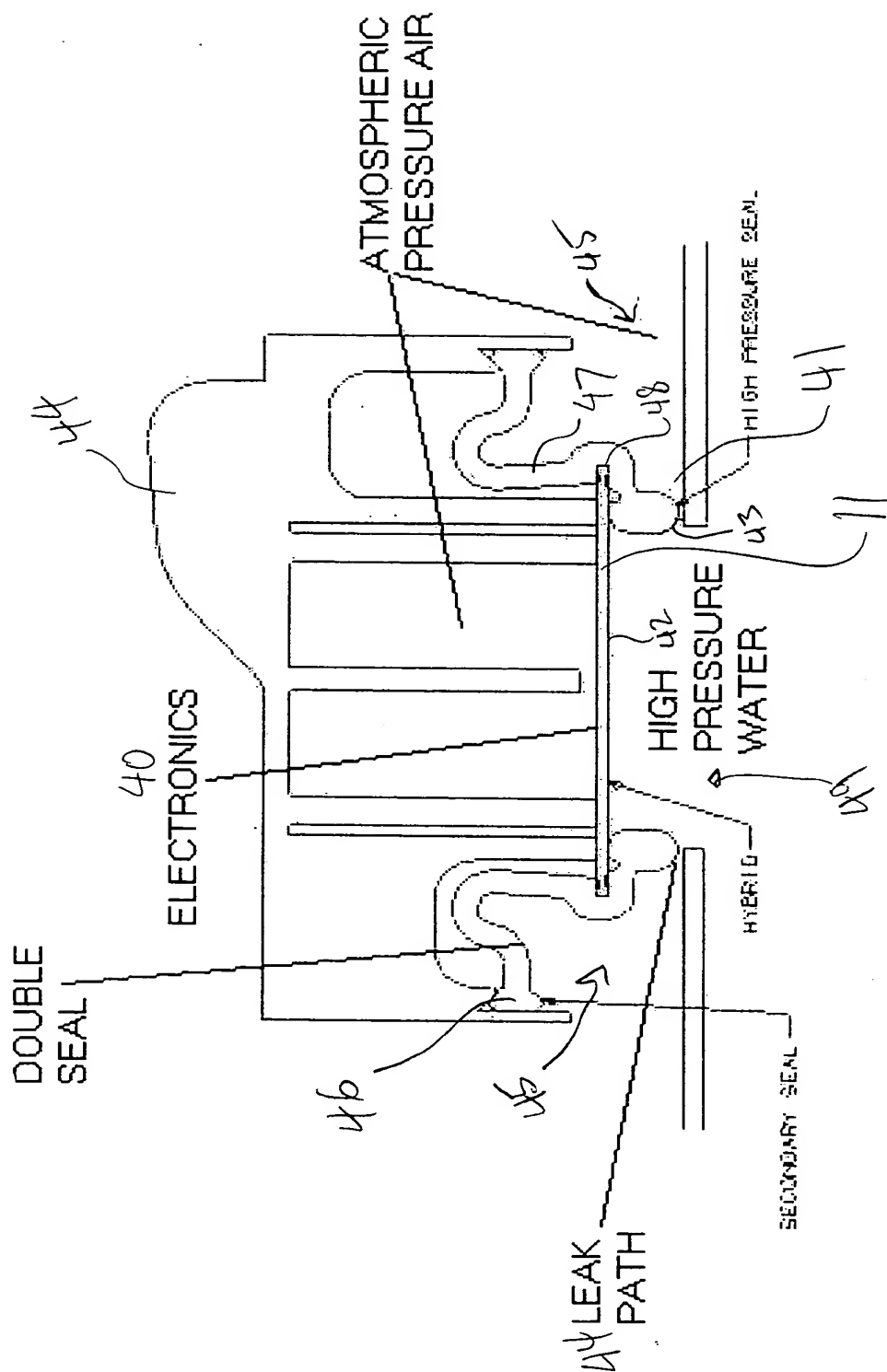


Fig 4

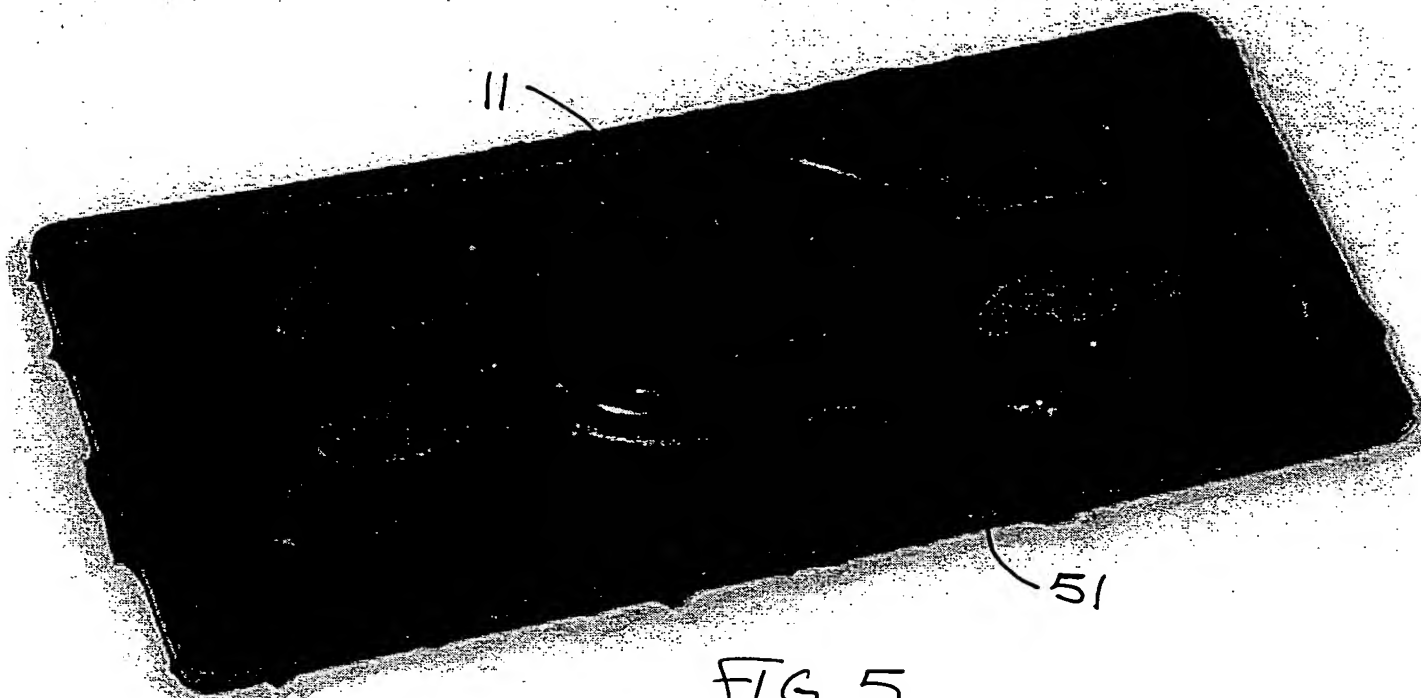


FIG 5

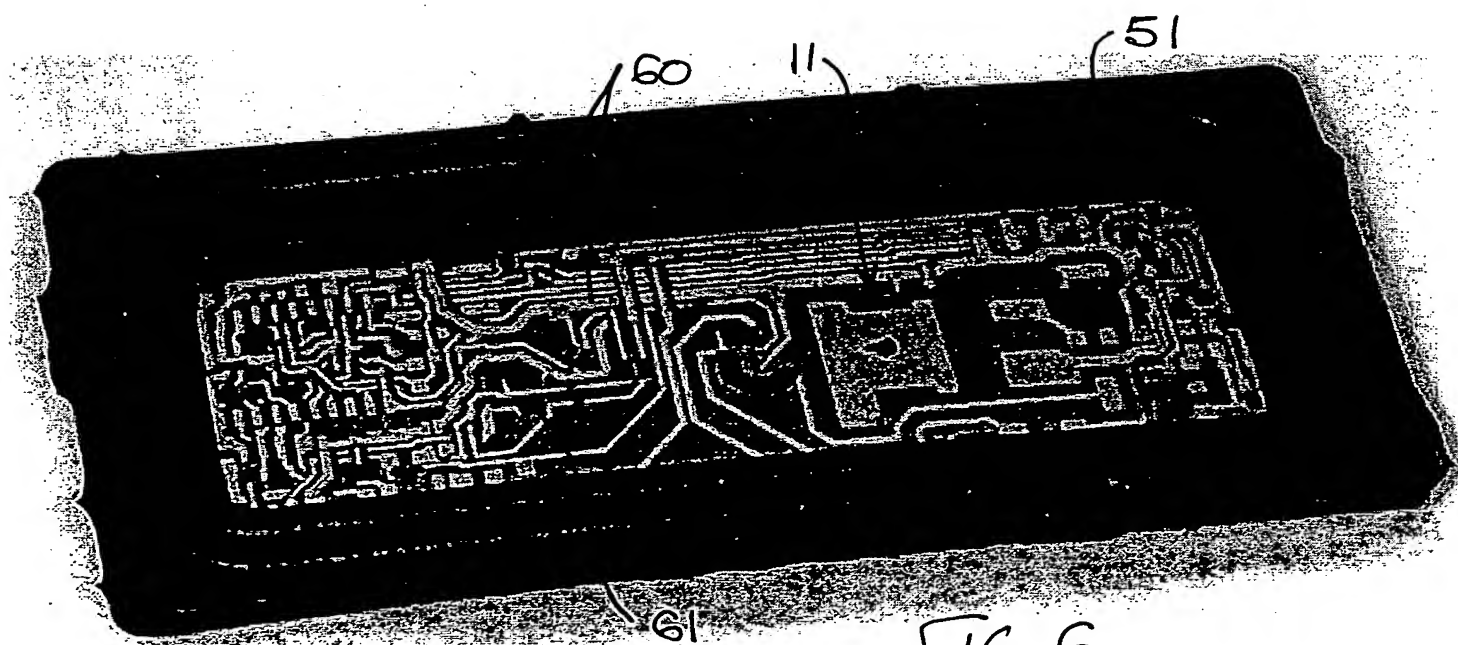


FIG 6

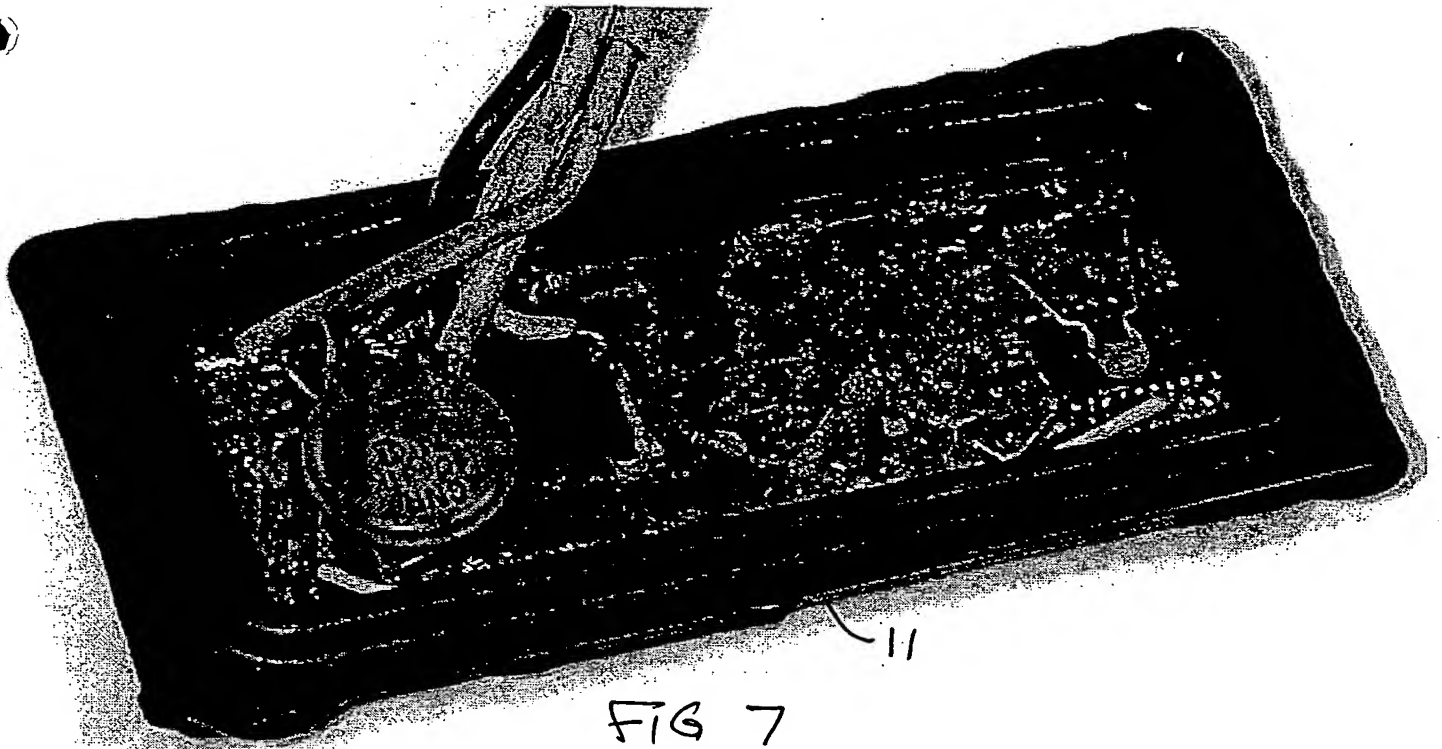


FIG 7

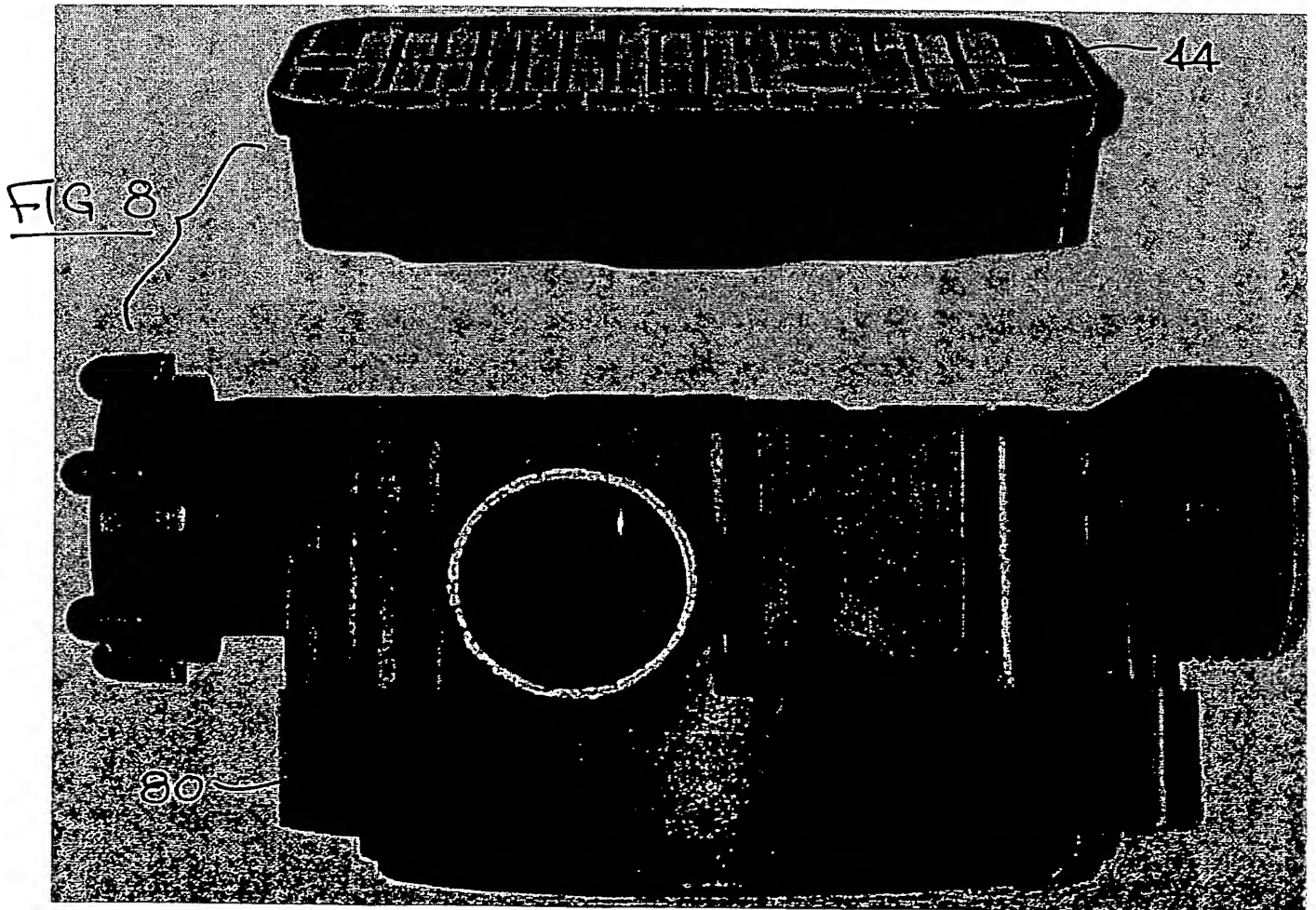


FIG 8

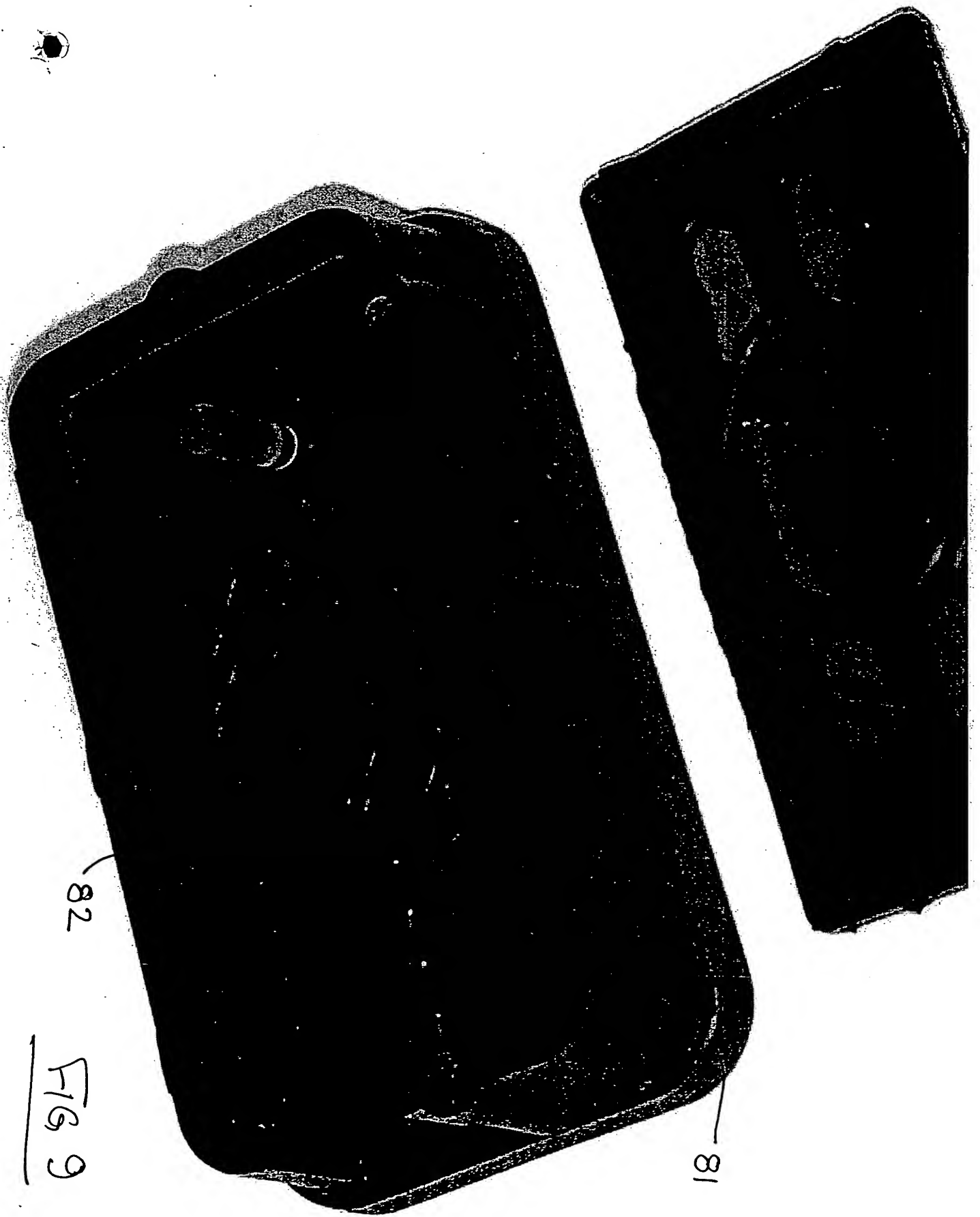


FIG 9

FIG 10

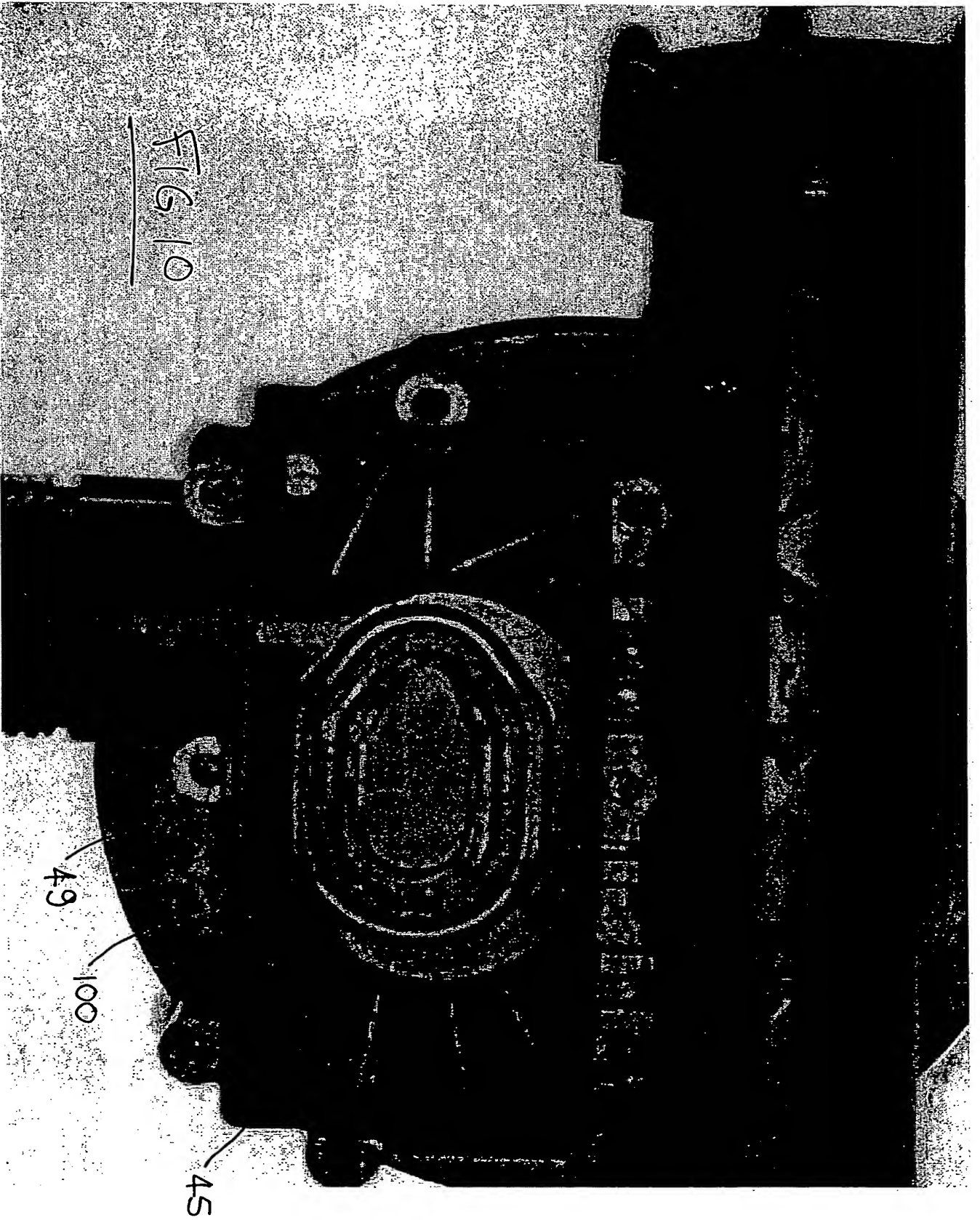
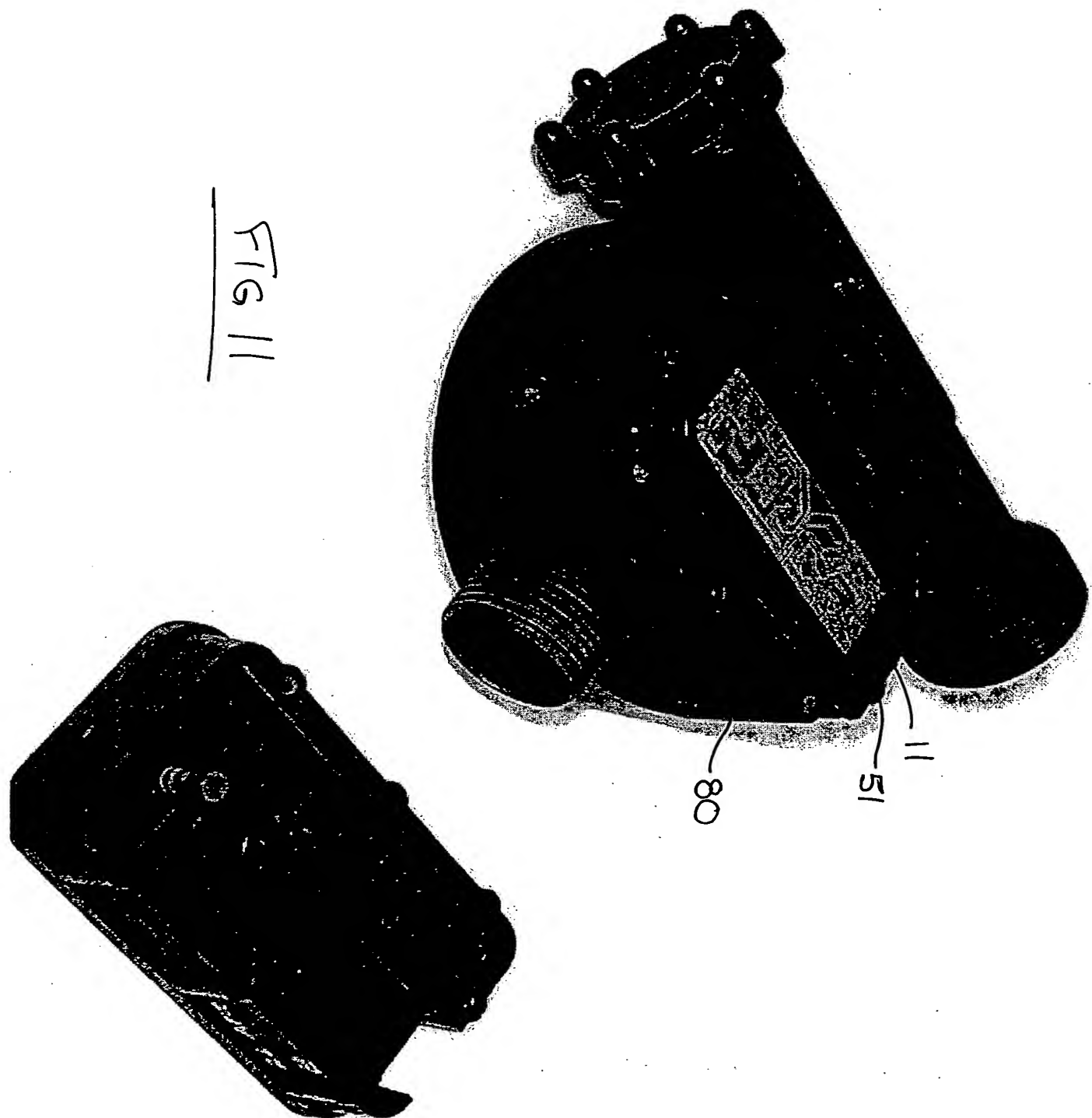
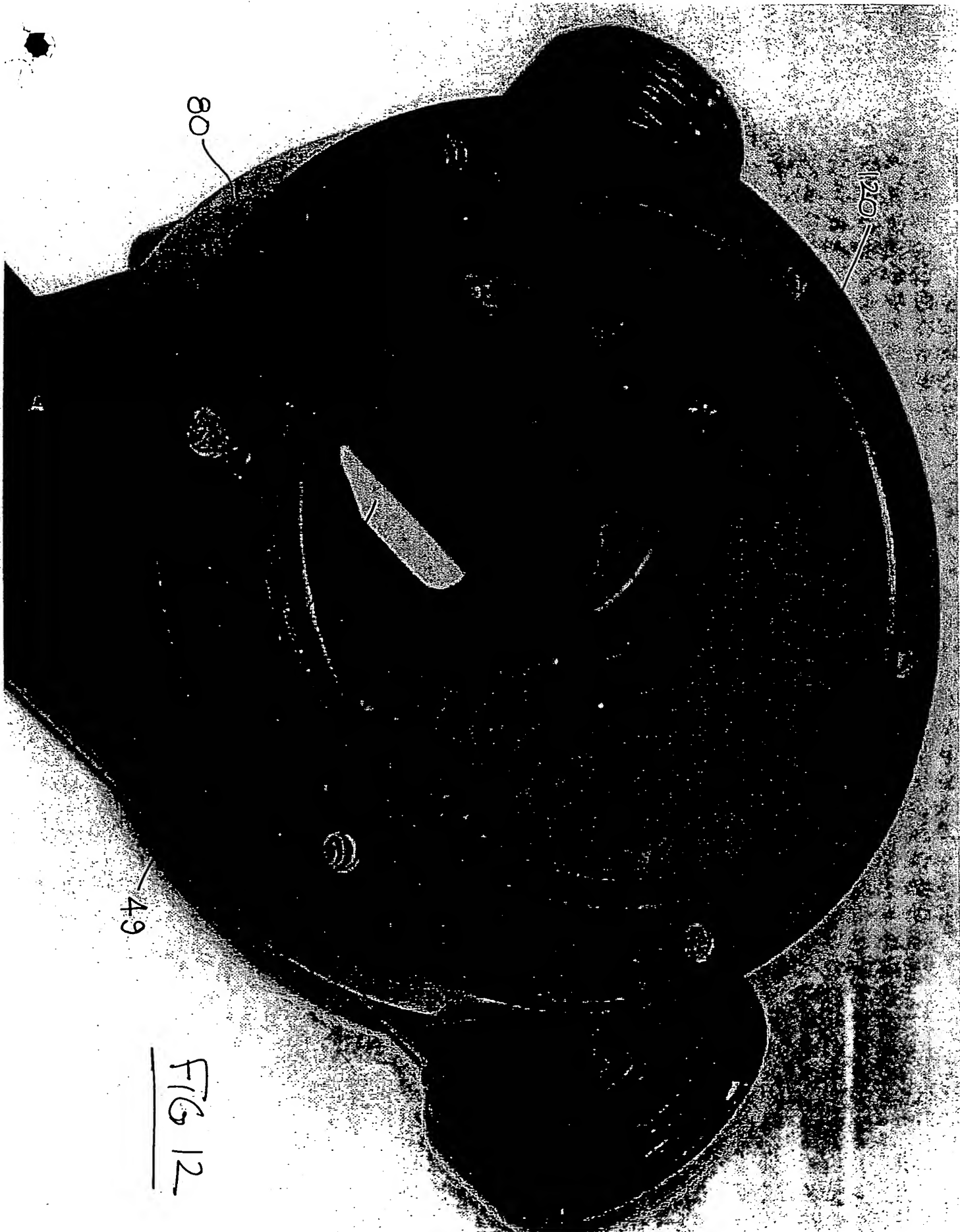




FIG 11





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